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The role of expectancy and proactive control in stress regulation: A neurocognitive framework for regulation expectation

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HIGHLIGHTS

- Low expectancy to deal with stressful events may result in less initiation of proactive control. Anticipation is related to specific neurocircuits and the ability to deal with stressors
- Our approach can be used to develop and fine-tune interventions to facilitate proactive control.

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ABSTRACT

When confronted with stressful or emotionally arousing situations, regulatory abilities should allow us to adaptively cope. However, depressed individuals often have a low sense of perceived control and are characterized by a negative expectation bias regarding their ability to deal with future stressful events. Low expectancy concerning the ability to deal with future stressful events may result in less initiation of proactive control, a crucial mechanism of cognitive control reflecting sustained and anticipatory maintenance of goal-relevant information in the dorsolateral prefrontal cortex to optimize cognitive performance. In this theoretical review we integrate a diverse body of literature. We argue that the expectancy of an individual's regulatory abilities prior to the presentation of an arousing event or stressful task will be related to anticipation and proactive up- or downregulation of specific neurocircuits *before* the actual encounter with the stressful event occurs, in a manner that can be either adaptive or maladaptive. Moreover, we discuss the important role of self-esteem as well as the ability to accept the situation when coping is not possible. Our approach has implications for a broad range of disorders and conditions in which stress regulation plays a role, and can be used to guide the use of recently developed clinical interventions, as well as to fine-tune interventions to facilitate proactive control.

Contents

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When we are confronted with situations or thoughts perceived as unpleasant, aversive or threatening, a series of biological and psychological processes is activated, generating a coordinated response. This so-called stress response is triggered when an individual's well-being or health is threatened. Relational or financial problems, unpredictability, an acute threat, or a challenging situation such as a job interview are examples of stressful situations or stressors that can initiate a stress response. Regulatory abilities, which we call *stress regulation*, generally allow us to cope with these situations in an adaptive way. However, there are large individual differences in how well people handle life stressors. Indeed, problems with *stress regulation* are thought to play a central role in the development and clinical course of depression (Hooley, Orley, & Teasdale, 1986; Hankin, 2008; Morris, Ciesla, & Garber, 2010). It has also been suggested that, over time, depressive episodes can be triggered by progressively milder and milder stressors (Monroe & Harkness, 2005; but see also Anderson, Monroe, Rohde, & Lewinsohn, 2016).

Research shows the important role of *stress regulation* in the development of different forms of psychopathology, such as depression, where psychosocial stressors are strongly implicated in the triggering of new episodes (Kendler, Thornton, & Gardner, 2000). Understanding the role of stressors in depression requires consideration of the interaction between biological, cognitive and environmental factors (De Raedt & Koster, 2010). Vulnerability to the effects of stressful events can be conceptualized as a trait-like latent endogenous process related to genetic, as well as other biological and psychological variables (Gotlib, Joormann, Minor, & Hallmayer, 2008; Ingram & Siegle, 2009).

Cognitive control, which is a crucial concept related to resilience to stressors, refers to processes that allow adaptive changes in information processing and behavior to current goals. Numerous studies have documented the role of prefrontal circuits in cognitive control (i.e., regulation) over stressful events (e.g., Baeken et al., 2014), as well as negative emotions (e.g., Leyman, De Raedt, Vanderhasselt, & Baeken, 2011) and painful physical stimuli (e.g., Strigo, Simmons, Matthews, Craig, & Paulus, 2008). However, our ability to deal with stressful events goes far beyond dealing with stressors that occur in the moment. Anticipation of future stressful events is an important component of emotion processing (Phillips, Drevets, Rauch, & Lane, 2003). It also influences acute emotional experiences (Kirsch, 1985). Simply knowing that we have an adaptive response to the stressor available can reduce aversiveness, decrease anxiety prior to exposure to the stressful event and reduce anticipatory physiological arousal (Gatchel & Proctor, 1976).

In this theoretical review we start from depression but take an essentially transdiagnostic approach and seek to integrate a diverse body of literature. Braver (2012) has recently developed a cognitive control framework distinguishing between proactive and reactive modes of control (the Dual Mechanisms of Control Framework). Proactive control occurs before the onset of a stimulus and involves preparatory processes that serve to enhance coping with conflict or challenge when it is presented. It is a crucial mechanism of cognitive control reflecting sustained and anticipatory maintenance of goal-relevant information in the dorsolateral prefrontal cortex (DLPFC) to optimize cognitive performance. Reactive control, in contrast, can be thought of as a corrective mechanism. Reactive control involves recruiting processing resources to resolve conflict when that conflict is actually occurring (Braver, 2012). Building on this perspective, we suggest that if depressed (or other vulnerable) individuals have negative expectations concerning their ability to deal with future stressful events, this may result in less initiation of proactive control. That is, the expectancy of an individual's regulatory abilities prior to the presentation of an arousing event or stressful task will be related to the anticipation and proactive up- or downregulation of specific neurocircuits *before* the actual encounter with the stressful event occurs. This will influence the actual regulatory response and will also have implications for the development of a balanced self-esteem. In other words, we argue that *expectations* about an upcoming stressful event shape the subsequent neuro-regulatory response in a manner that can be either adaptive or maladaptive. Although we will mainly focus on depression, this approach has also implications for a broad range of disorders and conditions in which stress regulation is considered to play a role. It may also provide a framework that can also be used to develop and fine-tune clinical interventions to facilitate proactive control.

Our review is not intended to be an exhaustive consideration of all the literature in the areas we discuss. Rather, our goal is to provide a framework within which several distinct and diverse literatures might be integrated. We begin by providing a step-by step overview of all the building blocks of our neurocognitive framework, starting with the role of cognitive control and perceived control in emotion reactivity and emotional adjustment to stressful experiences. We then explain the role of expectancy, anticipation and proactive control in the person's ability to regulate stress, and consider the neural substrates of these processes. We also further clarify the relationship of expectancy, anticipation and proactive control in emotion regulation and highlight how inter-individual differences such as self-esteem (actual and ideal self-esteem) and the tendency to accept (or resign oneself to the situation) when coping is not possible are related to regulatory control. Finally, we propose our integrated model and emphasize its clinical implications.

1. Cognitive control and emotion reactivity

A functional balance between ventral (ventral anterior cingulate cortex (ACC)) and dorsal compartments in the brain (dorsal ACC, DLPFC) is thought to be necessary to maintain homeostatic control over emotion arousing stimuli (for an overview, see Ochsner & Gross, 2005). Negative information is more personally relevant for depressed people (increased bottom-up reactivity), who show impairments (decreased top-down control) in their abilities to exert cognitive control over negative thinking (De Raedt & Koster, 2010). It has further been proposed that decreased regulatory control leads to increased rumination and sustained negative affect (Koster, De Lissnyder, Derakshan, & De Raedt, 2011). Consistent with this, neural systems that are dysfunctional in depression include circuitries related to emotional reactivity, cognitive control and rumination.

Results from a large meta-analysis of neuroimaging studies reveal that, compared to healthy individuals, people diagnosed with major depression have higher baseline activity in the pulvinar, a large nucleus in the thalamus (Hamilton et al., 2012). Moreover, when exposed to negative stimuli, depressed people demonstrate greater responses in the amygdala, insula, and dorsal ACC, and lower responses in the dorsal striatum and DLPFC than do healthy comparison participants. Based on the role of the pulvinar nucleus in emotional attention and awareness as well as its connectivity with amygdala, insula and dorsal ACC, Hamilton and colleagues proposed that elevated baseline pulvinar activity could potentiate the brain's salience network to respond negative information.

It is also possible that some of these neurocognitive characteristics might reflect trait vulnerability for depression. For example, Hooley and coworkers (Hooley, Gruber, Scott, Hiller, & Yurgelun-Todd, 2005; Hooley et al., 2009) have demonstrated that, relative to healthy controls, symptom free formerly depressed individuals responded to criticism with less activation in the DLPFC and increased activation in the amygdala. These findings are especially relevant given the reliable link between criticism and symptom relapse in depressed patients as well as patients with other disorders (Butzlaff & Hooley, 1998).

2. Perceived control

How we perceive our current situation has important implications. The simple perception of having control over painful stimuli (even when this is not the case) activates the dorsal ACC, right dorsolateral, and bilateral anterolateral prefrontal cortices (Wiech et al., 2006). These are brain areas that are related to different forms of cognitive and emotional control. This suggests that perception of control is related to the same neurocircuits that are also implicated in actual control. Indeed, cognitive control has been defined as "the belief that one has at one's disposal a response that can influence the aversiveness of an event" (Thompson, 1981, p. 89).

Research has also demonstrated that people who are criticized by someone they perceive as being highly critical of them are less able to activate neurocircuits related to regulatory cognitive control over their emotions than are people who are criticized by a family member that they do not perceive as being highly critical (Hooley, Siegle, & Gruber, 2012). More specifically, people high on perceived criticism show increased amygdala activation and decreased activation in prefrontal regulatory regions — even when the critical remarks they receive are not more severe or harsh than the critical comments heard by participants who regard their family members as less critical of them. This again supports the idea that perceptions may play a central role in shaping how we handle stressful experiences.

It has also been observed that higher perceived control is associated with better emotional adjustment to stressful experiences such as bereavement, even after accounting for the effects of other variables such as neuroticism (Frazier, Steward, & Mortensen, 2004). Yet depressed individuals often have a low sense of perceived control (Wardle et al., 2004).

3. Expectancy

The observation that depressed patients are characterized by low perceived control is consistent with the observation that people who are depressed have a negative expectation bias regarding their ability to deal with future stressful events, promoting a passive coping style (Alloy et al., 1999). The concept of expectancy is a central common core of personality dispositions related to different achievement areas (Haugen & Lund, 1999). It is also highly related to how we cope with stressful events.

Does knowing what to expect help us to handle stressful or conflict situations? The answer here appears to be yes. In experimental research, it has been demonstrated that when one expects that a cognitive conflict will occur (for example on certain trials) this may decrease the subsequent experience of conflict during task performance (Gratton, Coles, & Donchin, 1992).

In the laboratory, one way that conflict can be created is through the use of the Stroop task. In the classic Stroop task the person is asked to name the color of a printed word. One some trials the word and the color of the word are congruent (e.g., the word "blue" printed in blue ink). On other interference (or conflict) trials, the printed word and the color of the ink are incongruent (e.g., the word "green" printed in blue ink). In these tasks, expectancy can be manipulated by providing cues that inform the participants whether an upcoming target will or will not involve conflict (e.g., congruence or incongruence between color and meaning of the word) versus providing uninformative cues that provide no such relevant information. Behavioral responses are faster after informative than after uninformative cues (Aarts, Roelofs, & Van Turennout, 2008). This suggests that expectancy leads to adjustments in control. Importantly, in line with the above-mentioned role of the ACC in conflict monitoring, event related fMRI has revealed that ACC activity is larger after informative than after uninformative cues. This is the case even when the information provided is only that the upcoming target will not evoke response conflict. Such findings suggest that the ACC is involved in anticipatory control in a general way, independent from whether conflict will or will not actually occur. Interestingly, after informative cues, the left DLPFC is more active during the actual processing of the incongruent as compared to the congruent targets, highlighting its role in the implementation of cognitive control (for an overview, see Vanderhasselt, De Raedt, & Baeken, 2009).

The DLPFC might also have an important role in the active maintenance of expectancy based goal-relevant emotional information. This is nicely illustrated in an experiment that used an emotional variant of the Stroop task. More specifically, participants had to indicate whether a facial expression was neutral or fearful in conditions where a congruent or an incongruent word was printed on top of a face picture. For example, in an incongruent trial the word "neutral" was printed on a fearful face. Expectancy for incongruent trials was manipulated by increasing the proportion of control-demanding incongruent trials (65% incongruent trials), which results in strategic adjustments in behavior and implementation of cognitive control processes. Functional MRI data revealed a switch in cognitive control strategy based on condition. In the low expectancy task (i.e., when incongruent trial was unlikely) participants showed a reactive event-related activation of a medial and lateral cognitive control network and the right amygdala. In the high expectancy condition, proactive, sustained activation of right DLPFC was apparent (Krug & Carter, 2012).

Going beyond correlational data Vanderhasselt et al. (2007) used Repetitive Transcranial Magnetic Stimulation (rTMS) to study the causal relationship between activity in the right DLPFC and expectancy related processes. rTMS is an important technique because it provides researchers with a non-invasive way of transiently activating local processing in neural networks in the brain. As in the experiment by Krug and Carter (2012), Vanderhasselt and colleagues manipulated participants' expectancies for incongruent stimuli in a (non-emotional) Stroop task, by adapting the ratio of congruent/incongruent trials. When the expectation of an incongruent trial was high (meaning that participants expected to have to name the color of the presented word rather than simply read the word) *and* after DLPFC activity was increased using high frequency rTMS, participants showed a decreased response time. This was found on both congruent and incongruent Stroop trials, although the findings were more pronounced on incongruent trials. No behavioral changes were apparent after sham placebo rTMS stimulation. These findings suggest that increased activity in right DLPFC results in an overall improved attentional preparatory set, underscoring the role of the right DLPFC in general expectancy processes. The findings further suggest that greater activation in right DLPFC permits enhanced strategic top-down attentional processes under conditions where conflict is expected. In another study using a task switching paradigm, it was also observed that cued (a light informed participants about an upcoming switch trial) switching from one modality (visual) to another modality (auditory) was influenced by right DLPFC stimulation. In contrast, uncued switching was not influenced by stimulation (Vanderhasselt, De Raedt, Baeken, Leyman, & D'Haenen, 2006). All these findings suggest that expectancy increases DLPFC related anticipatory preparation to deal with an upcoming conflict.

4. Anticipation and proactive control

Recently, it has been demonstrated that cognitive effort exerted during anticipation of an emotion eliciting stimulus is related to lower cognitive effort when confronted with that stimulus (Vanderhasselt, Remue, Ng, & De Raedt, 2014). In this latter study, participants' pupillary responses (as a proxy of cognitive effort, related to DLPFC) were recorded while they were naturally responding to emotional stimuli. The anticipation of a stressor also elicits cardiovascular and affective responses, and the ability to recover may also be a crucial process related to stress resilience. In a study by Waugh, Panage, Mendes, and Gotlib (2010) a group of speech-givers was compared to a group who only anticipated giving a speech. Both groups exhibited similar cardiovascular recovery (decreased heart rate and increased respiratory sinus arrhythmia). However, in the anticipation group, those who showed no recovery from negative affect showed less cardiovascular recovery, suggesting that failing to recover from anticipatory stress has physiological costs. Interestingly, using an experimental design with neurostimulation (rTMS), it has also been demonstrated that increased DLPFC activity is related to a decreased cardiovascular stress response (Remue et al., in press).

Depressed patients have not only difficulties inhibiting a dominant response to negative versus positive situations and stimuli, but show also deficiencies in the anticipation phase of this process. This has been demonstrated in an Event Related Potentials (ERP) study in which expectancy for upcoming emotional conflict was induced by a cue (Vanderhasselt et al., 2014). Vanderhasselt and colleagues have demonstrated that the poorer inhibition of negative information that was characteristic of depressed patients was associated with a longer duration of a dominant ERP topography and with a stronger activity in the bilateral dorsal ACC, likely reflecting enhanced need for more reactive control during the inhibition of the negative stimulus. Importantly, the ERP data were indicative of a failure to exert efficient proactive cognitive control during the preparation period for the upcoming conflict stimulus (abnormal modulation of the Cued Negativity Variation component). Moreover, based on the results it could also be ruled out that this effect was simply caused by an overall breakdown in motivation. This is consistent with other findings showing that low motivation in depressed individuals is not the reason for cognitive task impairments (e.g., Whitmer & Banich, 2010).

Taken together, the results of the studies we have described so far suggest that enhanced anticipation of conflict during a preparatory period is related to sustained right sided DLPFC activity. This decreases the need for reactive control (which is related to the dorsal ACC) when actually experiencing the conflict.

The ACC can be conceived as a bridge between subcortical emotion processing and prefrontal cognitive control, integrating signals from the ventral parts of the ACC and the dorsal ACC (Bush, Luu, & Posner, 2000). The dorsal ACC sends signals to the DLPFC to enhance attentional control when conflict is perceived (Hopfinger, Buonocore, & Mangun, 2000; MacDonald, Cohen, Stenger, & Carter, 2000). The DLPFC has thus an important role in both anticipatory processing and the actual implementation of cognitive control upon conflict detection (see also Braver, 2012). Many studies have shown that the DLPFC initiates cognitive control over emotions by causing inhibition of the amygdala, a subcortical region implicated in emotion processing (Siegle, Thompson, Carter, Steinhauer, & Thase, 2007). Although based on our overview, the left DLPFC appears to be mainly related to actual control (e.g., Aarts et al., 2008), whereas the right DLPFC seems more involved in the maintenance of goal related information (e.g., Vanderhasselt et al., 2006), caution is warranted because lateralization might be highly dependent on the emotional nature of the paradigms (neutral versus negative), and on specific characteristics of the tasks used (for a review, see Vanderhasselt et al., 2009). This underscores the influence of specific task properties in frontal lateralization.

Cognitive control includes abilities to hold abstract goals in mind, to provide "top-down" attention allocation, updating information in working memory, selecting and switching to task relevant responses, while inhibiting thoughts or actions that are irrelevant to or incompatible with these goals (Banich, 2009). The result of successful anticipation of stressful situations, leading to more efficient reactive control during the actual confrontation with the event, might dampen amygdala activity and increase a person's ability to regulate stress.

It deserves mention that the effects of anticipation and expectancy on neurocircuits involved in the regulation of emotional processes also overlap with circuitries related to expectancy in pain processing. In a recent study (Atlas et al., 2012), a placebo manipulation was combined with a potent opiate, and participants' knowledge of drug delivery was manipulated in an open-hidden design. The opiate produced the most pronounced effects in the ACC, which was strongly associated with pain affect. Expectancies, as revealed by comparing the open and hidden administration, activated lateral and ventromedial prefrontal cortices and reduced responses in amygdala and pain-processing regions. In another study (Amanzio, Benedetti, Porro, Palermo, & Cauda, 2013), the left ACC, right precentral, and lateral prefrontal cortex were activated during expectation of analgesia. Interestingly, regions involved in physical pain, such as the ACC, seem to overlap with emotional pain (Eisenberger, 2012).

To summarize, the key point here is that, even prior to the presentation of an arousing, conflicting or physically painful event, expectancy-related preparation begins, which is a crucial process in stress regulation and recovery The specific dorsal neural correlates of this preparation are related to anticipation and to the proactive up- or down regulation of the implicated neurocircuits. Importantly, all of this happens *before* the actual encounter with these stressful events ever occurs.

5. Expectancy, anticipation, proactive control and emotion regulation

Depressed individuals typically have low expectancies concerning their ability to deal with future stressful events. Indeed, negative evaluations of the future are central to the cognitive model of depression (Beck, 1976), and hopelessness is a clinical feature of both severe and more mild depressions. Expectations about being unable to cope with future-oriented concerns are also found in people with anxiety disorders (Beck & Clark, 1988). This is likely to create stressful anticipation and less initiation of proactive control in challenging situations.

In the case of proactive control, it is important to emphasize that emotions unfold over time. Lazarus (1991) was one of the first to propose that the primary emotional appraisal of the situation, establishing the significance or meaning of the event to the organism, can be qualitatively different from the secondary emotional appraisal, directed at the assessment of the ability to cope with the consequences of the event. Humans can regulate their emotional states through a number of cognitive strategies, and the most adaptive strategies may be those that regulate emotions as soon as they are generated in order to reduce the emotion intensity over time. Gross (1998) proposes that emotions may be regulated either by manipulating the input to the system (antecedent-focused emotion regulation) or by manipulating its output (response-focused emotion regulation). According to the generic timing hypothesis (Sheppes & Gross, 2011), individuals' arousal levels increase over time during the development of the emotional response. As a consequence, its regulation is more efficient when initiated in the early stages of the emotional response, that is, when its intensity is still low, rather than later on, when it is full-blown. Indeed, emotions do not only occur during an emotion eliciting event, for example during a job interview. Preparatory brain/body responses can also arise when anticipating an emotion eliciting event, such as while traveling to the job interview. In several studies, anticipation of adversity has been related to DLPFC (e.g., Herwig et al., 2010) and amygdala activity (Abler, Erk, Herwig, & Walter, 2007). Based on this reasoning, we would expect emotion regulation to be most adaptive if it begins as early as possible — that is, as soon as people begin to experience the emotions that arise during the anticipation of a stressful event. The fact that anticipatory proactive regulation for upcoming stressors can lead to more efficient emotion regulation during the actual confrontation itself has been confirmed in an experimental neuroimaging study in which participants could anticipate the need to cognitively reappraise the content of aversive images and use reality checking to reduce anticipatory emotional arousal. In other words, they could remind themselves that they were lying in a scanner and not really experiencing the negative event depicted in the aversive image they were viewing (see Herwig et al., 2007). Brain activity during the anticipation of unpleasant (but still absent) stimuli was measured using fMRI. The use of anticipatory reappraisal was associated with increased activity in left prefrontal areas (e.g., medial and left DLPFC) that are typically associated with successful cognitive control. Moreover, amygdala activation associated with cognitive control correlated negatively with the reappraisal scores on an emotion regulation questionnaire (Herwig et al., 2007).

It is important to emphasize that the habitual use of strategies (such as reappraisal) to decrease anticipatory emotional arousal is related to the expectation of being able to deal with the stressful nature of the upcoming stimulus. But what if we have low expectations about our abilities to handle stressors or challenging situations? Our expectation of our ability to regulate our reactions to stressful events might be related, not only to our anticipatory deployment of cognitive resources but also to our proactive up- or down regulation of specific neurocircuits before the actual stressful encounter occurs. To the extent that we expect to be able to handle challenge, and begin proactive regulation in advance, we may experience more efficient emotion regulation during the actual confrontation itself. But if we have low expectations of our abilities to handle stressful situations, we may not engage in anticipatory deployment of cognitive resources and we may fail to proactively upregulate or downregulate the specific neurocircuits that would serve us best in the given circumstances. In other words, we are arguing that *expectations* about an upcoming stressful event can shape the subsequent *regulatory* response, both at the emotional and behavioral level.

To summarize, we can hypothesize that the expectancy of an individual's regulatory abilities prior to the presentation of an emotion arousing event or task will be related to an active anticipation and the proactive up- or downregulation of specific neurocircuits before the actual encounter with stressful events. This leads to increased emotion regulation abilities when actually confronted with stressors.

6. Self-efficacy, self-esteem and regulatory control

Self-efficacy and dispositional optimism are constructs that have been an important focus of empirical attention. Self-efficacy is defined as an individual's belief about his or her ability to produce and regulate events in his or her life (Bandura, 1982). Optimism has been defined as having generalized favorable expectancies regarding future outcomes and has been related to effortful control. Indeed, optimistic people exert effort to deal with challenges, whereas pessimistic people disengage from effort (Carver & Scheier, 2014). Both self-efficacy and optimism are closely related to what we are referring to as regulation expectation to deal with stressful events. Self-efficacy (mainly as a moderator) is also highly related to resilience. People with a strong expectancy in their own self-efficacy try harder to cope with difficult situations or challenges than do people with weak expectancy in their own efficacy (Haugen & Lund, 1999). Moreover, in Bandura's theory of self-efficacy (Bandura, 1982), it is argued that, by mastering challenging situations a person gradually builds up his or her sense of self-efficacy. All of this underscores the dynamic nature of the interaction between a person's actual ability to regulate stressful events and his or her expectancy about being able to do so. Successful coping with stressful events might increase self-expectancy and also increase self-esteem. Moreover, real life corrective experiences might be the most potent way to activate neural systems underlying the development of new self-schemas (De Raedt, 2006).

In a similar vein, optimism predicts better subjective well-being in times of adversity (e.g. Scheier et al., 1989), which is in line with observations that optimism is linked to higher levels of engagement coping and lower levels of avoidance, or disengagement coping (for a review, see Segerstrom & Nes, 2006). Moreover, there is evidence that optimistic people are inclined to take proactive steps to protect their health (for an overview of characteristics of optimism, see Carver, Scheier, & Segerstrom, 2010).

In contrast, having low expectancies of success or past experiences of failure might have exactly the opposite effect. Cognitive theories of depression define negative self-schemas as memory structures based on past experiences that guide information processing and shape beliefs about the self, the world, and the future (Beck, 1967). Depressed individuals hold negative self-schemas and therefore are more cognitively reactive to stressful events, which re-activate negative thought processes (Teasdale, 1988), interfere with goal-directed thinking and behavior and decrease self-esteem. With regard to depression, in a large study ($N = 2855$) it has been demonstrated that, in formerly depressed individuals, stressful life events had a significant, negative impact on self-efficacy. In contrast, for those without prior depression, life events had no effect on self-efficacy (Maciejewski, Prigerson, & Mazure, 2000).

The relationship between expectancy and self-esteem is nicely illustrated in an fMRI study in which participants received feedback words that they had no possibility to control (Eisenberger, Inagaki, Muscatell, Haltom, & Leary, 2011). The words (e.g., shallow, boring, friendly) were ostensibly chosen by another individual who had listened to the participant's previously recorded interview. Unbeknownst to the participant, the other individual was a confederate and the feedback words were unrelated to the participant's actual performance. While in the scanner, participants were shown the feedback words that purportedly describe their performance. After viewing each word, they were then asked to rate their self-esteem (on a 1–4 scale). As might be expected, participants reported significantly lower self-esteem after receiving negative (versus positive or neutral) feedback. Lower self-esteem (on a trial by trial basis) was also associated with greater activity in dorsal ACC — a brain region that, as we have already noted, has been linked to conflict processing and to emotional pain. Crucially, participants whose self-esteem *decreased* from prescan to postscan showed *greater* medial prefrontal (MPFC) cortical activity, a region associated with self-referential processing (Lemogne et al., 2010) in response to the negative feedback, compared to participants whose self-esteem remained the same or improved. Specifically the ventral MPFC plays a crucial role in the construction, stabilization, and modification of self-representations (D'Argembeau, 2013). The findings of this study are thus in line with the idea that confrontation with uncontrollable stressful events such as negative feedback can lead to decreases in self-esteem, with an influence on VMPFC.

7. The role of ideal self-esteem

As argued by Haugen and Lund (1999), if the number and quality of successful achievements equal the expectancies of successful outcomes, one's self-esteem is protected or enhanced. From the perspective of abilities to regulate stressful events, self-esteem would be the product of positive experiences in dealing with stressful events, fuelling expectancies about future regulatory abilities. Coopersmith (1970, p. 245) defines self-esteem as "a comparison of one's actual performance and capacities with one's personal standards and aspirations." James (1890) states that self-evaluations depend on the degree to which the self's actual successes coincide with the self's aspirations. This illustrates the potential importance of differentiating between actual self-esteem and ideal self-esteem to understand the link between self-esteem and expectancies. The ideal self has been defined as a representation of attributes a person would like to have. The ideal self functions as an incentive for future behavior (Cross & Markus, 1991), underscoring its relationship with expectations about the ability to regulate behavior when confronted with adversity. Depression is characterized by biased negative expectancies about the ability to deal with problems, and depressed patients typically have low self-esteem (Clark, Beck, & Alford, 1999). Many studies have provided evidence for the role of discrepancies between ideal and actual views in depression (e.g., Moretti & Higgins, 1999). Moreover, it has been proposed that the actual–ideal discrepancy influences self-regulatory (Carver & Scheier, 1982), motivational (Markus & Nurius, 1986), and affective (Moretti & Higgins, 1990) processes.

Nonetheless, it is important to note that there are fundamental issues about what constitutes support for the actual–ideal discrepancy model and how the constructs should be measured to test predictions (see Scalas & Marsh, 2008). First, there are studies in which no support was found for the idea that each discrepancy correlates with a specific emotional state (e.g., Tangney, Niedenthal, Covert, & Barlow, 1998). Second, the simple actual–ideal difference score approach has been criticized (e.g. Marsh & Roche, 1996). A crucial issue is that it is not possible to distinguish between the variance specific to each measure. A multiple experiment study using Structural Equation Modeling showed that actual and ideal self can have a different effect on self concept (Scalas & Marsh, 2008). A critical issue is that both aspects of self-esteem may be high or low (and thus in both cases there is a similar absence of discrepancy). For this reason, discrepancy scores may be less valuable than a focus on the combination of ideal-self and actual-self, in such a way to allow the existence of all combinations (high–high; low–low; high–low; low–high). Moreover, concerning the measurement issues, self-report measures on self concept may be susceptible to response biases such as social desirability and self-presentation, and cognitive models assume that self-related schemata are not always consciously accessible and thus cannot always be reported upon (e.g., Young, 1994). Therefore, alternative implicit measurement procedures have recently been developed that operate in such a way that they do not depend on introspective access. In two recent studies using such an implicit measure, which enables the differentiation of ideal self and actual self-esteem, it was demonstrated that dysphoric individuals have higher ideal self-esteem, and lower actual self-esteem compared to healthy participants (Remue, De Houwer, Barnes-Holmes, Vanderhasselt, & De Raedt, 2013; Remue, Hughes, De Houwer, & De Raedt, 2014).

Within our formulation, low self-esteem (both actual and ideal) is hypothesized to be related to low expectancy about the ability to deal with stressors. However, high ideal self-esteem might not invariably be a positive thing. For example, high ideal self esteem might be related to a low tendency to accept in situations where the person fails in his or her efforts to regulate the stressor. In other words, it is the *combination* of actual and ideal self-esteem that we view as being uniquely related to expectancies as well as to be able to accept the possible inability to cope when dealing with future stressors, and not the simple ideal–actual discrepancy. Different combinations can be expected to lead to different anticipation processes, both at the cognitive and the neural level, eventually leading also to differences in coping success.

8. Accepting the inability to deal with stressors

The specific adaptive response to stress will depend very much on context. In real life threatening situations, it is not always adaptive to reappraise a situation as harmless. Some situations (such as being chased by a lion) require action, not reappraisal. In yet other situations, accepting (or coming to terms with the situation) may be the optimal coping strategy. Whereas self-efficacy is defined as being confident that one will cope well regardless of outcome (Bandura, 1982), we would maintain that accepting one's inability to cope is also an important and highly relevant factor. Some people might not be confident about their ability to cope in a given situation, yet be fully able to accept this. It is also the case that high self-efficacy is most likely to be beneficial in situations that are potentially controllable. When no control is possible, high self-efficacy might even be counterproductive (Stewart & Yuen, 2011). Dogged determination to exert control over an uncontrollable situation is not likely to be an optimal coping strategy in all cases. Instead, optimal coping will sometimes require an ability to disengage effort, *accepting* that there are no solutions that can be used to deal with the stressful event. In other words, *expectations* can be considered to be adaptive when they are both positive (I will be able to deal with this), and tempered with accepting if it becomes apparent that the problem cannot be solved (If I can't make this work, I will accept it). This is an important way in which our construct of regulation expectation differs from the construct of self-efficacy. It should also be noted that although accepting defeat in a situation where success is impossible is adaptive, accepting failure prematurely is not.

The important role of accepting in regulatory control is nicely illustrated in a study where mindfulness meditators and community-matched controls completed a Stroop task during which event related brain potentials were recorded. Meditators showed better cognitive control. Moreover, the link between meditation practice and cognitive control was explained by both emotional acceptance and increased brain-based monitoring of their performance (which was indexed by the Error Related Negativity signal) (Teper & Inzlicht, 2013).

9. An integrated model

Central to our model is the idea that individual expectancies concerning regulatory abilities will be related to anticipation and proactive up or down-regulation of specific neural circuits. This occurs in advance of the actual stressful event or emotional challenge being experienced. Moreover, how people prepare to cope with challenges or stressful experiences is a function both of their past coping experiences as well as their actual and ideal self-esteem. This sets the stage for proactive control. During exposure to the stressor, reactive control processes are also in play. The nature of and extent to which these are operative will depend, in large measure on the degree of proactive control that has already occurred. Being able to rise to a challenge also requires the ability to know when to quit. Some stressors cannot be handled by active coping. In such circumstances accepting this may be the optimal approach.

In Figure 1 we describe a model that outlines how actual and ideal self-esteem interact to create different expectancies for stress regulation. We also describe some of the neurocognitive predictions that stem from this model.

As illustrated in Figure 1, there are four combinations of ideal and actual self-esteem.

For individuals with *low actual* and *high ideal self-esteem*, expectancy to be able to regulate their behavior and emotions when confronted with stressful situations is predicted to be low. Such people will also have difficulties accepting the possibility that they might fail to meet their own high standards in dealing with the stressor. Indeed, low self-esteem is related to low expectancies about dealing with adversity (Tripp, Catano, & Sullivan, 1997), and combinations of ideal self and actual self has been related to feeling disappointed, dissatisfied, ineffective, and having a lack of interest in things (Higgins, 1987). When such individuals anticipate a stressful event, they will be characterized by passive but stressful anticipation, leading to increased negative self-referential thoughts, which is related to increased VMPFC activity, and increased amygdala activity. According to our formulation, this will lead to low ability to regulate the stressful situation, and failure in challenging tasks, both of which might further fuel actual negative self-esteem. Based on this reasoning, we might expect that an individual with high ideal self-esteem will set high personal standards but the combination with low actual self-esteem might lead to failure, creating a vicious cycle of stressful anticipation and subsequent disappointment.

People with both *high actual* and *high ideal* self-esteem are predicted to have a high expectancy about their ability to regulate stressors, combined with a low tendency to accept failure. Such people might be characterized by ambitious striving and active stressful anticipation when faced with an upcoming challenging situation. This stressful anticipation might, however, lead to depleted cognitive resources, decreased DLPFC activity and increased amygdala activity. Accordingly, we would predict that these people would also experience difficulties coping with stressors and any negative experiences would render their high self-esteem fragile. Based on our model, we might further expect that people with high actual and high ideal self-esteem would

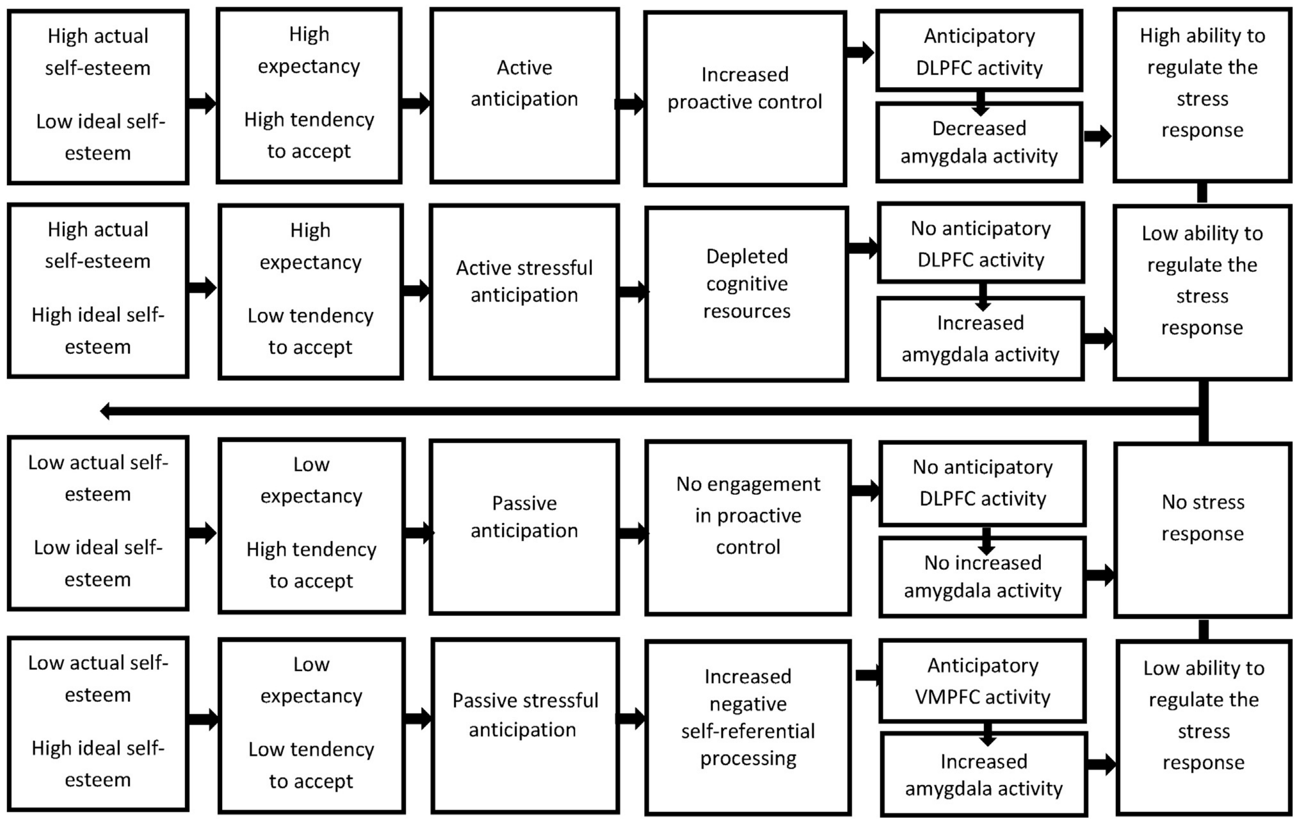

Fig. 1. Outline of the Regulation Expectation Framework.

be characterized by rigid perseveration and difficulty disengaging from their goals in an effort to meet their high standards and protect their self-esteem.

In cases where *low actual* self-esteem is combined with *low ideal* self-esteem we would predict a passive style with low expectancies and a high tendency to accept the inability to cope when anticipating challenges, and no engagement in proactive control, as well as a failure to activate specific neurocircuits. This may be accompanied by a relatively weak stress response. People with a profile of low actual and low ideal self-esteem would be predicted to have low approach motivation, and to anticipate future events in a passive way.

Finally, *high actual* self-esteem and *low ideal* self-esteem would be related to high expectancy to regulate stressors, and also to high tendency to accept failure in circumstances where it is not possible to deal adequately with the specific challenge. It is in such people that we would expect to see increased proactive control and anticipatory left DLPFC activity, leading to effective control over emotions and decreased amygdala activity. At the behavioral level, this would translate into high ability to regulate the stressful situation, successful coping outcomes and preserved actual self-esteem.

10. Clinical implications

The expectations patients hold regarding the effects of psychotherapy have long been considered a key ingredient and common factor of successful psychotherapy (e.g., Goldfried, 1980). Indeed, it has been shown that positive outcome expectancies for treatment predict better therapy outcomes (for a meta-analysis, see Constantino, Arnkoff, Glass, Ametrano, & Smith, 2011). Moving beyond this, however, the neurocognitive expectancy framework we have outlined has several other important clinical implications. These concern the potential importance of both increasing positive expectancies and also fostering an ability to accept when coping is not possible. In the sections below, we discuss specific approaches that might be valuable with respect to these constructs.

10.1. Increasing positive expectancies

Increasing positive expectancies is important because these fuel anticipatory processes, leading to increased proactive control in such a way that there is less need for reactive control to cope with stressful events. This in turn would increase the ability to cope with stressors, resulting in more positive experiences. These experiences would in turn strengthen self-esteem, which might subsequently be a buffer for new depressive episodes. Indeed, depressed individuals with sudden gains outside of the context of treatment have significantly higher self-esteem compared to non-sudden gainers (Kelly, Roberts, & Bottonari, 2007). In contrast, after negative experiences with stressful events, decreased self-esteem would likely influence the anticipation of similar future events, leading to the activation of dysfunctional schemas and self-reflective negative thoughts, and decreased expectancy of the ability to cope before the actual confrontation with the event.

Both Cognitive Behavior Therapy (CBT) and Neurocognitive Therapies (NT) (De Raedt, 2015) provide experiences that, in our view, are capable of influencing the way people perceive their environments and facilitating the development of new positive expectancies. For example, in CBT, the patient is encouraged to process schema-incongruent information to develop more adaptive schemas regarding the self, the world and the future. Beck (1967) has emphasized that behavioral experiments in CBT are important because they have the potential to provide corrective experiences — experiences that facilitate the development of more adaptive schema content, which would eventually lead to more positive expectancies. There is also robust evidence for the crucial importance of the behavioral component of CBT, which even outperforms the effect of the cognitive component (Dimidjian et al., 2006). Positive expectancies might lead to active anticipation and increased proactive control, and eventually more positive experiences with stressors, ultimately influencing self-esteem. Importantly, using techniques such as cognitive restructuring, expectancy related cognitions can also be targeted directly. Anton, Dunbar, and Friedman (1976) even developed anticipation training for the treatment of depression, to foster these expectancy related cognitive changes.

However, whereas CBT treatments can be successful in fostering positive experiences concerning the ability to cope with challenging situations to influence negative self-schemas, this could be problematic in depressed patients. Indeed, although CBT is undoubtedly an effective form of treatment, not all patients derive benefit (Cuijpers et al., 2013). Research with healthy individuals has indicated that exposure to uncontrollable stressors leads to passivity, decreased performance on cognitive tasks and negative affect (e.g., Kofta & Sedek, 1989), whereas exposure to stressful situations that can be escaped or modulated by learning new behavioral responses leads to unimpaired or even improved performance on similar cognitive tasks (e.g., Eisenberger, Park, & Frank, 1976). As stated byKaiser, Hubley, and Dimidjian (2014) behavioral treatment starts from the idea that engagement in active behaviors in the pursuit of goals will ultimately lead to decreased depressive symptoms and improved daily functioning. However, this is challenging because these behaviors might be inherently stressful. The fact that stressful events have a negative influence on cognitive control in depressed people (Vanderhasselt & De Raedt, 2009) increases the risk of exposing these patients to negative (and not positive) experiences. Indeed, studies based on the concept of learned helplessness have shown that depressed individuals fail to benefit from behavioral control, showing poor cognitive performance after both controllable and uncontrollable exposure to stressor, (e.g., Miller & Seligman, 1976). In this perspective, our new framework highlights the importance of interventions that facilitate both (1) the creation of new experiences to influence the way patients perceive their environment to increase positive expectancies, and (2) which simultaneously increase cognitive control. To facilitate these processes, the use of NT procedures has been proposed as a new therapeutic intervention for depression (Baert, Koster, & De Raedt, 2011; Siegle et al., 2007). Here, we can distinguish between two different cognitive training procedures that might lead to increased stress resilience. (1) Visuospatial cueing tasks to train attention away from negative towards positive information, influencing the way individuals perceive their environment, which would eventually lead to new corrective experiences with more positive aspects of the situation; and (2) cognitive control training to increase the ability to shift away from negative internal presentations in working memory, which would lead to decreased rumination and facilitate reappraisal of negative to positive expectancies (De Raedt, Vanderhasselt, & Baeken, 2015). However, studies have shown that these training procedures might be effective in dysphoric individuals (Wells & Beevers, 2010), but less so in depressed patients (Baert, De Raedt, Schacht, & Koster, 2010, but see Siegle et al., 2014), possibly because depressed individuals are, given their dysfunctional DLPFC related cognitive abilities, unable to deploy their cognitive resources.

Based on our observation that depressed individuals are characterized by dysfunctional proactive anticipatory processing, leading to an increased need for reactive control (Vanderhasselt et al., 2014), it might be important to combine both CBT and NT. Using two different strategies each tackling a different aspect of the process (CBT: content level of cognition; NT mechanistic level of cognition) might increase the power to create positive expectancy about the ability to deal with stressful events in depressed patients. Moreover, psychoeducation about the working mechanisms of the intervention could also fuel positive expectancies. This combination might lead to active anticipation and increased proactive and reactive control, and positive experiences with stressors, influencing self-esteem.

10.2. The role of adaptive accepting

Based on our framework, we would maintain that therapy should not only be focused on behavioral strategies (behavioral experiments and activation) and negative self-schemas (cognitive restructuring) – which are the main components of CBT –or the enhancement of cognitive control (CCT). Adaptive forms of expectancy (i.e., high expectancy, high tendency to accept) also need to be considered.

The ability to accept potential negative outcomes of situations could be targeted via tailored CBT techniques, such de-catastrophizing (cognitive restructuring). Moreover, recently developed computerized Cognitive Bias Modification of Interpretation (CBMi) techniques such as reappraisal training might also be very promising to accomplish these goals (Woud, Postma, Holmes, & Mackintosh, 2013). These computerized CBMI techniques have the unique feature that they can be adapted to target very specific appraisals. These could include the ability to accept that one might be unable to cope with certain stressors.

Actual and ideal self-discrepancies also provide a specific treatment target. For those individuals who have difficulties accepting the possibility that they might fail to meet their own high standards (ideal self), therapeutic strategies such as Mindfulness Based Cognitive Therapy (MBCT: Segal, Williams, & Teasdale, 2002) could be used. It has been demonstrated that MBCT is a promising intervention for decreasing vulnerability (Chiesa & Serretti, 2011), and can influence discrepancies between actual self and ideal self (Crane et al., 2008), emphasizing that MBCT may protect against increases in self-discrepancy in individuals who are vulnerable to relapse to depression, and may facilitate a shift in the goals of self-regulation. Interestingly, it has also been shown that MBCT has a positive influence on cognitive control for emotional information (De Raedt et al., 2012). Moreover, Bryant et al. (2013) have demonstrated that the response to exposure therapy (which itself is a very stressful procedure) in post-traumatic stress disorder can be enhanced by preparing patients beforehand by emotion regulation therapy including mindfulness.

11. Future research

Our review provides empirical support for the sub-processes of the framework we describe. However, future research should test the framework as a whole. This can be achieved by measuring actual self and ideal self esteem (using both questionnaires and implicit measures) in combination with a measure of all combinations between expectancy and the tendency to accept (high expectancy, high tendency to accept; high expectancy, low tendency to accept; low expectancy, high tendency to accept; low expectancy, low tendency to accept). The crucial test would be to investigate whether the combinations we propose would be related to anticipation and proactive control, and the ability to deal with stressors. Although there are excellent measures to index ideal and actual self-esteem (both implicit and explicit, see Remue et al., 2014), future research should be focused on the development of procedures to assess the dimensions of expectancy/acceptance tendency. We have now developed a questionnaire to measure each of the combinations of expectancy and the tendency to accept during anticipation. This questionnaire is designed to be used with a context manipulation that involves a stressful task. Research to validate this instrument is currently ongoing.

Notwithstanding the importance of more empirical research, however, our framework has heuristic value for clinical practice. We provide a new approach that may help clinicians and clinical research understand how the mechanisms of action of existing therapeutic interventions might target different aspects of stress resilience. Indeed, there is currently no comprehensive framework capable of combining all these different aspects to increase our understanding of the underlying mechanisms of action of existing interventions targeting crucial components such as expectancy. Importantly, we do not propose new concepts or interventions as such, but a framework combining existing knowledge to understand how their mechanisms of action target different aspects of stress resilience.

12. Conclusion

The Neurocognitive Framework for Regulation Expectation holds the potential to enhance understanding and encourage further investigation of how self-esteem, expectancies, and the tendency to accept are related to proactive and reactive control. The framework also highlights how novel techniques such as NT, CBMi, and MBCT could be used to influence these processes. This could hold promise for the refinement or the combination of these approaches with current treatment strategies such as CBT, and provide indications for the use of these techniques in a personally-tailored way. Regions sensitive to CBT are primarily lateral frontal regions (Graham et al., 2013), which are related to both proactive and reactive control (e.g. Vanderhasselt et al., 2014). CBT, in which patients use behavioral and cognitive strategies to reduce negative thoughts and attitudes and corresponding reactivity, leads to changes in brain activity in these prefrontal regions (DLPFC, dACC) (e.g., Goldapple et al., 2004). CBT not only requires patients to test their interpretations and beliefs via behavioral experiments, leading to positive expectancies, but cognitive restructuring can also be used to influence an adaptive accepting attitude. Neurocognitive training (e.g., Browning, Holmes, Murphy, Goodwin, & Harmer, 2010) as well as meditation (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007) have also been related to changes in the above mentioned dorsal areas. However, although it has been concluded that mindfulness allows flexible emotion regulation by engaging frontal brain areas to dampen amygdala activation, and that there is a large overlap between areas activated during mindfulness, psychotherapy, and those activated by placebo induced expectancy (for a review, see Chiesa, Brambilla, & Serretti, 2011), the exact mechanisms underlying these specific changes are not yet understood.

Current interventions may be not specific enough in targeting the mechanisms associated with the causation and/or maintenance of psychopathology. The fact that there is such frequent relapse – even after initially successful treatment (Beshai, Dobson, Bockting, & Quigley, 2011) – indicates that stable risk factors for depression are not (sufficiently) changed through traditional interventions. Our framework could be used to guide practice and further research into the influence of cognitive control mechanisms that subserve adaptive emotion regulation strategies such as reappraisal of stressful events, by facilitating shifting processes towards positive information, leading to more positive expectancies for future events. Indeed, adaptive emotion regulation strategies are an important predictor for resilience, the phenomenon of maintaining one's mental health even when confronted with adversity (Kalisch, Müller, & Tüscher, 2014). It is of crucial importance to know (1) which components of therapy could be most beneficial, and (2) what might work best for whom. Concerning the latter, our framework highlights the key roles of self-esteem and adaptive accepting when control is not possible, and suggests that these warrant increased consideration in the development of more personalized treatment approaches.

Finally, we would note that, although our framework is mainly focused on depression, it is important to keep in mind that many different disorders such as anxiety (Ball, Ramsawh, Campbell-Sills, Paulus, & Stein, 2013) and substance abuse (Gowin, Mackey, & Paulus, 2013) involve the same neurocircuits with the DLPFC playing a key role. Depression is also a disorder that is frequently comorbid with a broad range of clinical conditions. For these reasons, our approach should be regarded as more transdiagnostic than depression-specific.

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